Absorption correction:
empirical *via* $\psi$ scans
(Fair, 1990)
$T_{min}$ = 0.969, $T_{max}$ = 0.979
2312 measured reflections
2062 independent reflections

$\theta_{max}$ = 26.3°
$h = 0 \rightarrow 9$
$k = -17 \rightarrow 0$
$l = -11 \rightarrow 11$
3 standard reflections
frequency: 120 min
intensity decay: 1%

*Refinement*

Refinement on $F$
$R$ = 0.048
$wR$ = 0.060
$S$ = 1.68
1715 reflections
170 parameters
H atoms: see below
$w = 1/[\sigma(F)^2 + (0.02F)^2 + 1.0]$

$(\Delta/\sigma)_{max}$ = 0.01
$\Delta\rho_{max}$ = 0.22 e Å$^{-3}$
$\Delta\rho_{min}$ = −0.25 e Å$^{-3}$
Extinction correction: none
Scattering factors from *International Tables for X-ray Crystallography* (Vol. IV)

Table 1. *Selected geometric parameters (Å, °)*

| | | | |
|---|---|---|---|
| C14—C5 | 1.411 (2) | C3—C4 | 1.362 (3) |
| C14—C13 | 1.441 (2) | C9—C10 | 1.359 (3) |
| C14—C1 | 1.407 (2) | C1—C2 | 1.370 (3) |
| C5—N6 | 1.386 (2) | C2—C3 | 1.391 (3) |
| C4—C5 | 1.408 (3) | C1—N8 | 1.467 (2) |
| N6—N7 | 1.284 (3) | C11—C12 | 1.377 (3) |
| C8—C13 | 1.412 (2) | N8—O1 | 1.218 (2) |
| C8—C9 | 1.408 (3) | N8—O2 | 1.211 (2) |
| C8—N7 | 1.388 (2) | C10—C11 | 1.395 (3) |
| C13—C12 | 1.403 (3) | | |
| C5—C14—C13 | 116.5 (1) | C8—C9—C10 | 120.0 (2) |
| C5—C14—C1 | 115.2 (2) | N6—N7—C8 | 120.6 (1) |
| C13—C14—C1 | 128.4 (1) | C1—C2—C3 | 119.6 (2) |
| C14—C5—N6 | 123.4 (2) | C14—C1—C2 | 123.5 (2) |
| C14—C5—C4 | 121.4 (1) | C14—C1—N8 | 120.8 (2) |
| N6—C5—C4 | 115.2 (2) | C2—C1—N8 | 115.6 (1) |
| C5—N6—N7 | 120.0 (2) | C4—C3—C2 | 119.7 (2) |
| C13—C8—C9 | 120.7 (2) | C13—C12—C11 | 121.0 (2) |
| C13—C8—N7 | 123.5 (2) | C1—N8—O1 | 117.6 (1) |
| C9—C8—N7 | 115.9 (2) | C1—N8—O2 | 118.1 (2) |
| C14—C13—C8 | 115.6 (1) | O1—N8—O2 | 124.2 (2) |
| C14—C13—C12 | 126.9 (2) | C9—C10—C11 | 120.3 (2) |
| C8—C13—C12 | 117.5 (2) | C12—C11—C10 | 120.4 (2) |
| C5—C4—C3 | 120.5 (2) | | |
| C13—C14—C5—N6 | 5.2 (2) | C14—C5—C4—C3 | −0.8 (3) |
| C13—C14—C5—C4 | −176.2 (2) | C9—C8—C13—C12 | 4.0 (3) |
| C1—C14—C5—N6 | −175.1 (2) | C14—C1—N8—O1 | −65.7 (2) |
| C1—C14—C5—C4 | 3.6 (2) | C14—C1—N8—O2 | 116.1 (2) |
| C5—C14—C13—C8 | −7.3 (2) | C2—C1—N8—O1 | 110.4 (2) |
| C13—C14—C1—N8 | −8.1 (3) | C2—C1—N8—O2 | −67.8 (2) |

The structure was solved by direct methods. Most of the H-atom positions were located by difference synthesis and refined isotropically; the remaining ones were calculated geometrically and a riding model was used during the refinement process.

Data collection: *MolEN* (Fair, 1990). Cell refinement: *MolEN*. Data reduction: *MolEN*. Program(s) used to solve structure: *SHELXS*86 (Sheldrick, 1990). Program(s) used to refine structure: *MolEN*. Molecular graphics: *ORTEP*II (Johnson, 1976). Software used to prepare material for publication: *MolEN*.

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# Homolycorine hydrochloride dihydrate†

FRANCESC VILADOMAT,[a] JAUME BASTIDA,[a] CARLES CODINA,[a] XAVIER SOLANS[b] AND MERCÈ FONT-BARDIA[b]

[a]*Departamento de Productes Naturals, Facultat de Farmácia, Universitat de Barcelona, Diagonal s/n, E-08028 Barcelona, Spain, and* [b]*Departamento de Cristal·lografia, Mineralogia i Dipòsits Minerals, Universitat de Barcelona, Marti i Franqués s/n, E-08028 Barcelona, Spain. E-mail: xavier@natura.geo.ub.es*

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## Abstract

The chirality of homolycorine has been determined by X-ray crystallographic analysis of the hydrochloride dihydrate, $C_{18}H_{22}NO_4^+ \cdot Cl^- \cdot 2H_2O$. Homolycorine is an

† Alternative name: 9,10-dimethoxy-1-methyllycorenan-7-one hydrochloride dihydrate.

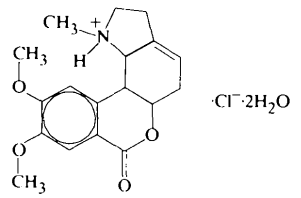
*Amaryllidaceae* alkaloid, which was isolated from *Narcissus confusus* pugsley. The structure is compared with those reported for other alkaloids of the homolycorine/lycorine series.

## Comment

Homolycorine, which is widely distributed in the *Narcissus* L. genus (Bastida *et al.*, 1997), is one of the principal constituents of *Narcissus confusus* (Bastida *et al.*, 1987). This plant, belonging to the *pseudonarcissi DC* sect., is an endemic *Amaryllidaceae* species from the centre of the Iberian Peninsula and was collected in Béjar (Salamanca) during the flowering period. The genus *Narcissus* belongs to the tribe *Narcisseae*, which is one of nine tribes in this family, and has a typical West-Mediterranean distribution, being extremely variable in Spain and Portugal where most species occur.

According to the literature, homolycorine has been described as a cytotoxic agent against fibroblastic LMTK cells and as an inductor of delayed hypersensitivity in animals (Weniger *et al.*, 1995; Gude *et al.*, 1988).

Little is reported on the chirality of alkaloids of the homolycorine/lycorenine series (Clardy *et al.*, 1972; Gopalakrishna *et al.*, 1978; Via *et al.*, 1989; Latvala *et al.*, 1995), thus the structural chirality hitherto has been reported with reservation. In order to determine it, we have analyzed the HCl salt of homolycorine, (I).




(I)

The Flack (1983) parameter for the given coordinates indicates that homolycorine hydrochloride possesses identical chirality to that which has been previously proposed for homolycorine (Bastida *et al.*, 1987; Wagner *et al.*, 1996; Latvala *et al.*, 1995) and opposite to that proposed in 17-epihomolycorine (Gopalakrishna *et al.*, 1978) or in eugenine (Via *et al.*, 1989). Recently, by single crystal X-ray analysis, we have found that *O*-methyllycorenine hydrochloride, obtained from *O*-methyllycorenine isolated from *Narcissus bujei*, possesses the inverse chirality to that described here (Labraña *et al.*, 1999).

The pyran ring shows a skew-boat form. The double-bond character of C3—C4 causes the non-aromatic $C_6$ ring to have a skew-planar form with C1 and C10b atoms out of the plane defined by the other four atoms. The indoline ring shows an envelope form with N out of the plane defined by the remaining four atoms. This conformation is similar to those observed in other homolycorine compounds. The protonation of the homolycorine molecule is at nitrogen.

Although not all the H atoms were located, hydrogen-bonding interactions are indicated by short intermolecular contacts. These involve N—H···O(water) [N···O5 2.701 (3) Å], water···water [O5···O6$^{i}$ 2.717 (4) Å; symmetry code: (i) $1+x, y, z-1$], water···$Cl^-$ [O5···Cl$^{ii}$ 3.108 (3); O6···Cl 3.139 (3); O6···Cl$^{iii}$ 3.196 (3) Å; symmetry codes: (ii) $2-x, \frac{1}{2}+y, 1-z$; (iii) $1-x, y-\frac{1}{2}, 2-z$], and produce a sheet polymeric network parallel to the (101) plane.

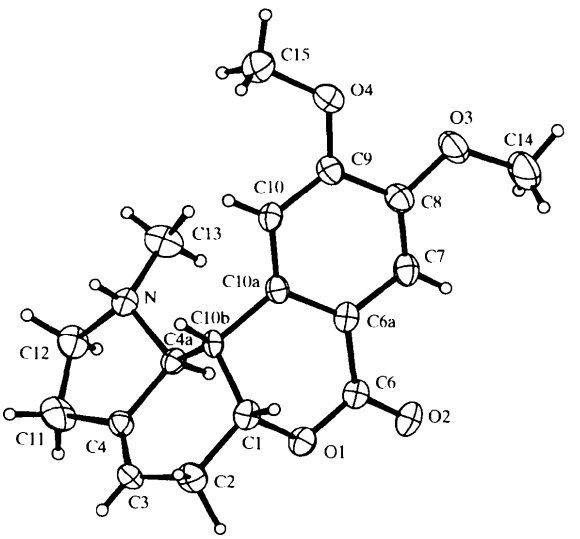



Fig. 1. Molecular structure of the homolycorine moiety showing 50% probability displacement ellipsoids. H atoms are shown as circles of an arbitrary radius.

## Experimental

Homolycorine was isolated from *Narcissus confusus*. The physical data of the isolated compound (m.p., $[\alpha]_D$, UV, IR, EIMS, $^1$H NMR, $^{13}$C NMR and CD) were in accordance with those reported previously (Jeffs *et al.*, 1985; Bastida *et al.*, 1987; Wagner *et al.*, 1996). Crystals for X-ray analysis were obtained by evaporation of water from an aqueous solution containing HCl.

*Crystal data*

$C_{18}H_{22}NO_4^+ \cdot Cl^- \cdot 2H_2O$
$M_r$ = 387.85
Monoclinic
$P2_1$
$a$ = 11.173 (4) Å
$b$ = 7.324 (5) Å
$c$ = 12.024 (8) Å
$\beta$ = 97.82 (4)°
$V$ = 974.8 (10) Å$^3$
$Z$ = 2
$D_x$ = 1.321 Mg m$^{-3}$
$D_m$ not measured

Mo $K\alpha$ radiation
$\lambda$ = 0.71069 Å
Cell parameters from 25 reflections
$\theta$ = 12–21°
$\mu$ = 0.229 mm$^{-1}$
$T$ = 293 (2) K
Prism
0.4 × 0.3 × 0.3 mm
Colourless

*Data collection*

Enraf–Nonius CAD-4 diffractometer
$\omega$–$2\theta$ scans
Absorption correction: none
2326 measured reflections
2214 independent reflections
1774 reflections with $I > 2\sigma(I)$
$R_{int} = 0.023$
$\theta_{max} = 29.96°$
$h = -15 \rightarrow 15$
$k = 0 \rightarrow 10$
$l = 0 \rightarrow 16$
3 standard reflections
frequency: 120 min
intensity decay: none

*Refinement*

Refinement on $F^2$
$R[F^2 > 2\sigma(F^2)] = 0.033$
$wR(F^2) = 0.057$
$S = 0.875$
2214 reflections
281 parameters
H atoms treated by a mixture of independent and constrained refinement
$w = 1/[\sigma^2(F_o^2) + (0.0202P)^2]$ where $P = (F_o^2 + 2F_c^2)/3$
$(\Delta/\sigma)_{max} < 0.001$
$\Delta\rho_{max} = 0.175$ e Å$^{-3}$
$\Delta\rho_{min} = -0.105$ e Å$^{-3}$
Extinction correction: *SHELXL*97 (Sheldrick, 1997)
Extinction coefficient: 0.007 (3)
Scattering factors from *International Tables for Crystallography* (Vol. C)
Absolute structure: Flack (1983)
Flack parameter = 0.06 (6)

Table 1. *Selected torsion angles (°)*

| | | | |
|---|---|---|---|
| C6—O1—C1—C10b | 51.9 (2) | C2—C1—C10b—C4a | −57.2 (2) |
| C10b—C1—C2—C3 | 34.2 (3) | C10—C10a—C10b—C1 | 141.6 (2) |
| C11—C4—C4a—N | 24.2 (2) | C6a—C10a—C10b—C1 | 36.3 (2) |
| C1—O1—C6—O2 | 167.5 (2) | C4a—C4—C11—C12 | −3.1 (3) |
| C1—O1—C6—C6a | −13.6 (3) | C4—C11—C12—N | −19.3 (3) |
| O1—C1—C10b—C4a | 62.0 (2) | | |

The positions of 13 H atoms were computed. 11 H atoms were located from a difference map and the remaining two (on water molecules) were not located. The computed H atoms were refined isotropically using a riding model and an overall $U_{iso}$, while the remaining H atoms were refined freely.

Data collection: *CAD-4/PC* (Kretschmar, 1996). Cell refinement: *CAD-4/PC*. Data reduction: *CFEO* (Solans, 1978). Program(s) used to solve structure: *SHELXS*-97 (Sheldrick, 1990). Program(s) used to refine structure: *SHELXL*97 (Sheldrick, 1997). Molecular graphics: *ORTEP* (Brueggemann & Schmid, 1990). Software used to prepare material for publication: *PLATON* (Spek, 1990).

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# (3*R*)-4,4-Dimethyl-2-oxotetrahydrofuran-3-yl (2*S*)-7-methoxy-2,3-dihydro-1,4-benzodioxin-2-carboxylate

MOSTAFA KHOUILI,[a]† M. DOLORS PUJOL,[b] XAVIER SOLANS,[c] MERCÈ FONT-BARDIA,[c] ABDELAMAN SOUIZI,[d] GERARD COUDERT[a] AND GERALD GUILLAUMET[a]

[a]*Institute de Chimie Organique et Analytique, associé au CNRS, Université d'Orleans, BP 6759, F-45067 Orleans CEDEX 2, France,* [b]*Laboratori de Química Farmacèutica, Universitat de Barcelona, Diagonal s/n, E-08028 Barcelona, Spain,* [c]*Departamento de Cristal·lografia, Mineralogia i Dipòsits Minerals, Universitat de Barcelona, Marti i Franqués s/n, E-08028 Barcelona, Spain, and* [d]*Laboratoire de Synthèse Organique et Agrochimie, Université Ibn Tofaïl, Faculté des Sciences, Kenitra, BP 133, Morocco. E-mail: xavier@natura.geo.ub.es*

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## Abstract

The structure of the title compound, $C_{16}H_{18}O_7$, a key intermediate in the synthesis of antagonist adrenergic agents, is reported. The 1,4-benzodioxin ring shows a half-chair form with a C$sp^3$ atom out of the plane

† Current address: Université Ibn Tofaïl, Morocco.